DTE Energy
Detroit Edison

Variable Speed Drive

State Energy Assessment Workshop

By:

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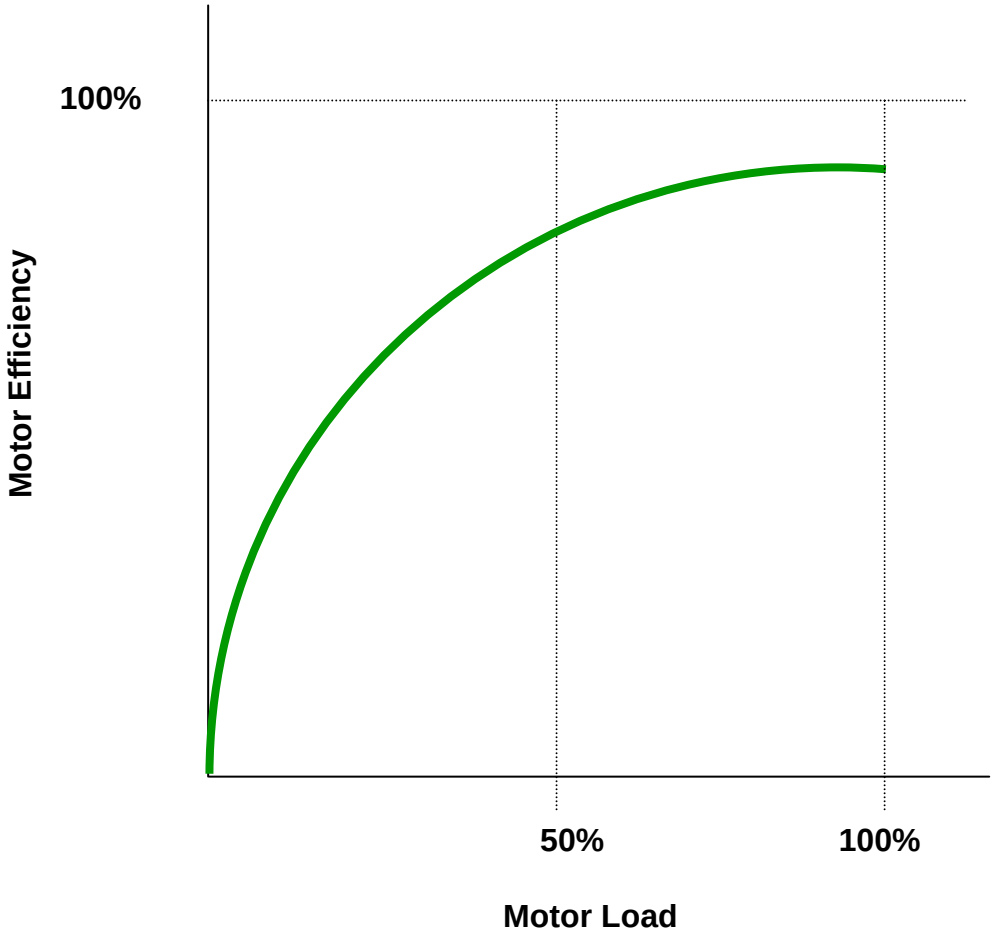
Overview

- Electric Motors are over 90% efficient when running at their rated loads. However, they are very inefficient at load-following, or running at part loads. Conventional electric motors typically use 60% to 80% of their rated input energy, even when running at less than 50% load.

- A 'Drive' is an electronic device that controls input power supply to an electric motor. Through electronic switching, a Drive can save energy by reducing the input power to a motor to match the running load.

Motor Efficiency



Energy Optimising Theory

- Motor Iron Losses (Magnetising Losses) are fixed at a Constant Voltage
- Around 55% of Motor Losses are Iron Losses
- Around 45% of Motor Losses are Copper and Friction Losses

Control Theory

- Motor Torque is Proportional to the Voltage Squared - 70%V = 49% Torque
- Current is proportional to Voltage
- Voltage Controls Motor Current and Torque

Working Definition: Drives

- There are a number of different terms used to describe the AC Drive. AFD, VSD, VFD and Inverters all are used but have the same meaning. The main purpose for all AC Drives is to control the operation of the AC motor with regard to speed and torque. **Drive:** A technology that controls a motor's **speed** to correspond with its load requirements

Speed Control Options

- **Drives:**
  - Adjustable Speed Drives (ASDs)
  - Variable Speed Drives (VSDs)
  - Variable Frequency Drives (VFDs)
  - Variable Frequency Inverters (VFIs)

- **Other Means:**
  - Hydraulic and Mechanical Methods
  - Electronic Devices
  - Load Management controls

Ranges of Applications

- VSD's have been used to provide significant savings in a number of applications. These include:
- Variable air volume (VAV) air conditioning systems.
- Chilled water pumping (eg secondary chilled water pumps).
- Exhaust air systems (eg dust extraction, paint shop exhaust, and fume cupboards).

Energy Efficiency – Common Drive Applications

- The most common application for a variable speed drive are large air handlers on building HVAC systems. This is because fans respond very well to speed control, the loads are always changing, and most of the time they are less than 100%.
- Pumps, air compressors, chillers and other large packaged equipment can be ordered with integral Variable Speed Drives and motors designed precisely for their application. The controls may even include total shut-off of the motor for as little as several seconds at a time during periods of light loads to achieve maximum savings.

Rules of Thumb on VSD Applications

- Assess all loads with throttled output
- Assess loads that vary by 30 percent or greater from highest to lowest during the motor's normal operating cycle
- Loads throttled continuously at 70 percent or less of rated output are good candidates
- Systems that deliver rated flow less than 40 percent of the time are good candidates

Economic Considerations

- Output profile of the application
- Cost of electricity
- Hours of operation
- Motor and drive costs

VSD and Pumps

Provide significant energy savings when:

- Pumps are operated at low flow rates
- Existing system has bypass control
- System has low static pressure (head).
- Local electricity costs are high
- Pump has steep design curve.

FANS

- Typical sized for maximum flow
- Systems typically operate at less than designed level
- Flow control is normally achieved using either an output damper or inlet guide vanes.

When to use VSD

There are five key points that should be considered when attempting to apply variable speed drives:

- optimize electrical performance
- eliminate unnecessary losses in the application
- eliminate high starting current losses
- use an energy efficient motor
- installation practices are most important

Harmonics and Power Factor

- Although they can improve displacement power factor (DPF), modern VSDs also create harmonics, which reduce real power factor. (Real power factor includes harmonics and DPF.) For instance, while a VSD can improve DPF to close to 1.0, the harmonics generated by the VSD can cause the real power factor to decline to between 0.75 and 0.80. These harmonic currents (most often the fifth and seventh harmonics) tend to exacerbate resistance losses and can even negate the transformer capacity benefits of improved DPF.
- To minimize harmonics problems, an increasing number of VSD manufacturers are packaging harmonics-mitigating equipment (such as line reactors or isolation transformers) with drives. These features can allow users to enjoy the full benefits of power factor improvement. In addition, this added equipment can significantly reduce the impact of VSD-generated harmonics on other electronic equipment, a benefit that should be especially attractive to value-conscious commercial and industrial users.

VSD Tips

- **VSDs Located too far from Motor**

  Pulse-width modulated (PWM) drives can cause significant damage to motors if the length of cable between the VSD and the motor exceeds 15 to 30 meters. (The number seems to differ by manufacturer.) Older motors with long cable runs may have shortened lives using PWM VSDs.

- **Mechanical Resonance**

  It is important to determine any mechanical resonance frequencies and to program the VSD to avoid steady operation at those speeds. These resonance frequencies, common in large fans, gears, and belt-driven systems, can cause significant damage through vibration.

- **Motor Compatibility**

  To ensure that the VSD and motor are compatible, either purchase them from the same company, or have the manufacturer test the VSD for compatibility with another company's line of motors.

VSD Tips

- How can you determine that the motor need VSD?

  When the motor is partially loaded, and when there is a need to reduce motor speed to reduce the flow of air in air handling unit as an example.

- By testing?

  When the amperage is a fraction of the motor rated amperage.

- If the phase voltage is different, what is the acceptable tolerance?

  Phase voltage difference may create unbalance. The acceptable tolerance is under 1% unbalance. Unbalances over 1% require de-rating of the motor per NEMA MG-1-1993, Rev 3.

- Where and how the controller is connected? It's size, an example.

  VSD is connected between motor and power supply. The VSD is sized the same as the motor size in most of the applications.

- Are there voltage limitations for the use of VSD?

  Yes there is voltage limitation, i.e. 480 volts. Any need for higher voltage is custom built.

VSD Limitations

- What if the application requires fixed Speed? Can you use VSD?
- No you can't use VSD on a fixed speed applications.
- So, what can you do to save energy?
- You may use intelligent motor controller,

  as in **Motor Boss**

Motorboss

- Basic Criteria
  - Fixed Speed Application
  - Variable Duty Cycle
  - Motor Should be unloaded for around 50% of the Load Cycle
  - Power Factor = < 0.63

Please Remember...

Motor Control Is Not An Exact Science…..

There Are Too Many Variables…..

The Best Anyone Can Do Is Estimate.

Motorboss

- Advantages Over Traditional Methods
  - Accurate Control Of Motor Current
  - Match Motor and Load Torque
  - Smooth Acceleration - ***soft-start***
  - ***Soft-stop*** - on Pumps
  - Energy Saving when Lightly Loaded

Remember……!

- Inverters Control Frequency and Voltage and are used on Variable Speed Applications.

- Motor Boss Controls only Voltage and Is Used on Fixed Speed Applications.

MotorBoss

- Conclusion – Electrical Benefits
  - Reduces Starting Current
  - Improves Supply Stability
  - Allows More Equipment to be connected to supply
  - Improves Motor Life

Motorboss

- Conclusion – Mechanical Benefits
  - Reduces Starting Torque
  - Prolongs Life of Driven Equipment
  - Reduced Maintenance
  - Improves Motor Life

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The End